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Karst Kamp Asbestos Deposits Gallatin County, Montana

Thomas L. Wilson

KARST KAMP ASBESTOS DEPOSITS

GALLATIN COUNTY, MONTANA

by

THOMAS L. WILSON

A Thesis

Submitted to the Department of Geology
in partial fulfillment of the
Requirements for the degree of
Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
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KARST KAMP ASBESTOS PROPERTY
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INTRODUCTION

The Karst Kamp Asbestos Property, although discovered nearly half a century ago, has never been adequately studied from the geologic standpoint, thus the author of this paper has chosen the problem of its genesis as his thesis in fulfilling the requirements for the degree of Bachelor of Science in Geological Engineering at Montana School of Mines.

Karst Kamp (Figure 1), a southwestern Montana recreation resort, is 32 road miles south of Bozeman on the east bank of the Gallatin River in a narrow V-shaped valley flanked on the west by the rugged Madison mountain range and on the east by the equally rough Gallatin range. The asbestos deposit itself lies approximately one-half mile northwest of the ranch on a heavily timbered "Alpine-like" slope nearly 1200 feet above the floor of the valley. An asphalt surfaced all-weather national highway, U.S. No. 191, passes directly in front of the ranch on the route between Bozeman and West Yellowstone, Montana, the western entrance to Yellowstone National Park. The nearest railroad is at Gallatin Gateway, Montana, 22 miles to the north. A wooden bridge crosses the river 1500 feet north of the Karst ranch, and a dirt road leads to the asbestos pit, climbing and crisscrossing the mountain at a 10 percent grade (Plate I, B, C; Plate II, A, B). Foot and horsetrails which lead to the deposit by more direct routes also take off from the bridge.

The author wishes to gratefully acknowledge the advice and assistance so readily given him by Dr. Eugene S. Perry who made available much information he was in possession of, and Mr. Forbes S. Robertson with his technical advice on microscopic identification. Both of these gentlemen are associated with the Department of Geology of Montana School of Mines. Much information was also supplied by Messrs. Charles Lester and C.M. Massey, owner and superintendent

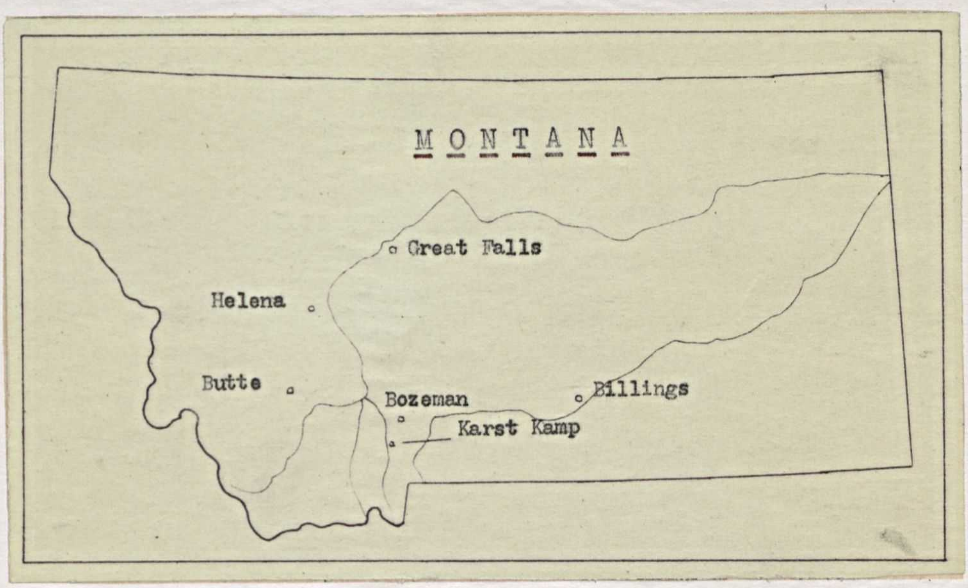


Figure 1.-- Index map of the State of Montana showing the location of Karst Kamp.

of the deposit respectively, as well as Mr. Peter F. Karst, discoverer of the deposit and original owner. Mr. Robert L. Pott generously give of his time and assistance in field work connected with this thesis.

The deposits have been opened by a main pit with which are associated a shaft and an undercutting adit, but there are also two small pits about one-quarter mile southwestward. Descriptions in this report deal essentially with the main pit.

HISTORY

The deposit was discovered in 1901 by Peter F. Karst while hunting on hills west of his ranch house. He shipped 800 tons of asbestos from his discovery in the next few years, transporting the material down the mountain on mule back and shipping the crude product to Milwaukee for beneficiation. Later, however, a gravity aerial tram and a small mill were constructed. Production was intermittant for the next several years, the U.S. Bureau of Mines reporting small tonnages in 1923, 1928, and 1933 to 1935. In 1935 the property was sold to the Karstolite Company which manufactured the asbestos into wall and ceiling insulation bearing the trade name of Karstolite. This company operated the deposit until 1938, when it was sold to the Montana Asbestos Company which operated until 1940, at which time the property was closed down.

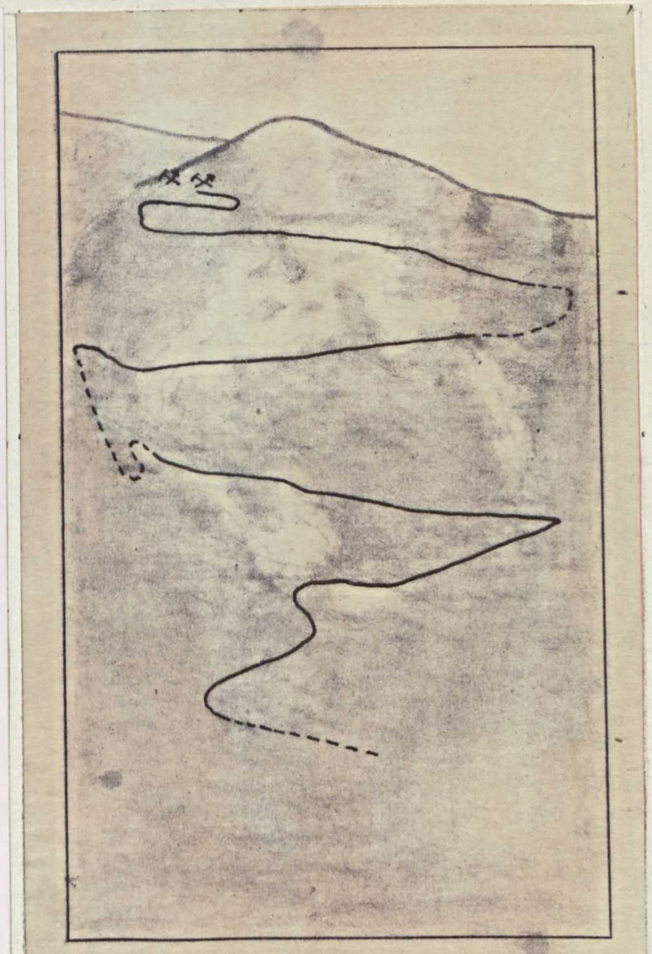
In 1947, Mr. Charles Lester formed the Inter-State Products Company, and in 1947 a road was constructed with a bull-dozer from the highway to the pit. Plans for building a new mill adjacent to the deposit, and for developing the property to its fullest extent are in process of execution in 1948.

PHYSIOGRAPHY

The Madison mountain range is a region of extremely rough mountainous topography (Plate I) with high peaks, precipitous slopes heavily covered with timber, and deeply incised canyons. Several peaks in the area have maximum altitudes of over 10,000 feet while the major valleys have an approximate average elevation of 4,800 feet. The elevation of Karst Kamp is 5820 feet. Evidences of glaciation

A.-- View looking south from asbestos mine.

B.-- View of asbestos-bearing hill, looking west.



C.-- Road on photograph "B."

PHOTOGRAPHS OF KARST KAMP AREA

A.— Beginning of mine road showing wooden bridge crossing Gallatin River. Roof of mill visible in upper left cornor.

B.— Mine road under construction.

PHOTOGRAPHS OF ROAD TO ASBESTOS MINE

can be seen high towards the peaks in the form of cirques. The upper reaches of the canyons also have their V-shapes slightly eroded to the typical glacial U-shape (Plate I, A) in addition to a few ill-defined moraines.

Out crops of the rocks composing the range are few except along ridges and above the timberline, locally there is a heavy mantle of soil with vegetation and slide rock. The surface material nearly always shows evidences of creep as a result of the steep slopes and strong water movement during the spring thaws. Mechanical erosion predominates as shown by the granular character of the soil and angular blocks of talus.

The hill upon which the deposit is located forms one of the extreme eastern slopes of the range, having an average inclination of about 30 degrees from the horizontal, and it is almost entirely covered by pine trees and range grass (Plate I, B).

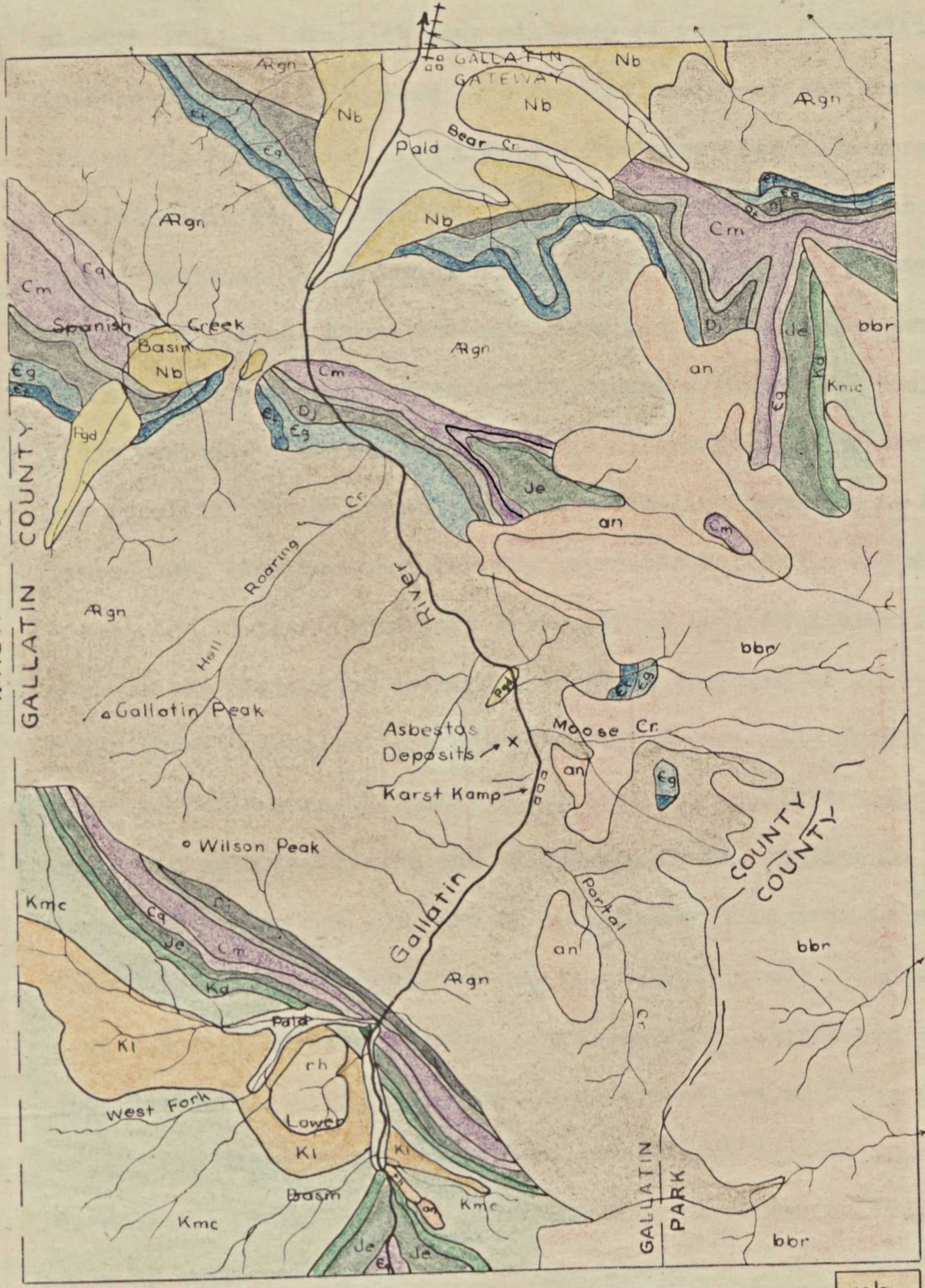
Water is drained from the area by the Gallatin River (Plate III) which flows north from Yellowstone National Park to the Three Forks of the mighty Missouri River. Feeding into the Gallatin are numerous small tributaries which trend east from the Madison Range side and west from the Gallatin Range. The deposit is on a south slope facing an unnamed intermittant stream flowing into the Gallatin River.

GENERAL GEOLOGY

Historical Geology

Regional

The rocks of the region (Plate III) reveal the geologic history of the area from the Archeozoic to Recent times with but few gaps, a



LEGEND

PLIESTOCENE
- Pald — Alluvium and drift
- Pgd — Glacial drift and moraines

NEOCENE
- Nb — Bozeman lake beds

CRETACEOUS
- Kl — Laramie formation
- Kmc — Montana and Colorado formations
- Kd — Dakota formation

JURASSIC
- Je — Ellis formation

CARBONIFEROUS
- Cq — Quodrant formation
- Cm — Madison limestone

DEVONIAN
- Dt — Three Forks formation
- Dj — Jefferson dolomite

CAMBRIAN
- Єg — Gallatin formation
- Єf — Flathead formation

ARCHEAN
- ARgn — Gneiss and schist

- rh — Rhyolite
- an — Andesite
- bbr — Basic andesitic breccia and flows

AREAL GEOLOGY

KARST ASBESTOS DEPOSITS

SCALE: 1 IN. = 4 MILES

Compiled from U.S.G.S. Three Forks Folio

T.L.W., 1948

stretch of time involving many millions of years. Pre-Beltian or Archean time is represented by a complex series of schists and gneisses called the Pony Series. An unconformity separates this formation from the Paleozoic sediments which are normal marine clastics and nonclastics. Rocks of the Ordovician and Silurian periods are completely missing; it is not known whether these rocks were eroded away or simply not laid down. An unconformity occupies the normal position of these periods. Shallow and deep seas alternated during the Paleozoic era resulting in conformable coarse shore-line deposits to deep-water limestones. Another unconformity separates Paleozoic and Mesozoic rocks, the younger formations being normal sediments with the exception of the Livingston formation which is composed of volcanic flows. While these volcanics were being deposited (probably from centers north of Yellowstone National Park) regional uplift commenced and continued into the Eocene and Oligocene epochs. Sediments laid down during this time are composed of the Bozeman lake beds which were formed in lakes occupying the valleys dammed by the Livingston volcanics and by earth movements. Later erosion, aggrevated by Eocene and Pliestocene glaciation, permitted the escape of these waters and caused the drainage to change from one of southerly to one of northerly direction. Recent erosion and alluvium have either removed or covered many of these sediments.

Local

The Karst asbestos deposits lie wholly within the Pony series of Archean rocks (Plate III). Very little is known of the early pre-Cambrian history, but it has been well established that the rocks had been subject to great regional stresses prior to the deposition of the pre-Cambrian Belt sediments which lie beyond the limits of the map. These sediments are composed in part of a conglomerate of Pony schists and gneisses. Further proof is held in the fact that many of the faults within the Pony Series are terminated by the unconformity separating the Archeozoic and Paleozoic eras. Folding and faulting of successively younger orogenies have resulted in a complex which has not been deciphered.

The entire series are literally crisscrossed by igneous injections, ranging from very basic dikes and sills to pegmatites. Most of these are of pre-Cambrian age since they are displaced by Archean faults. As will be shown later it was one of these basic dikes which led to the formation of the asbestos.

Subsequent deposition of Paleozoic and Mesozoic sediments has been entirely removed by erosion periods of Triassic and post-Cretaceous age. Orogenic movement of late Cretaceous to early Tertiary age raised the Madison Mountains to their maximum elevation and greatly accelerated the rate of erosion, which bared the schists and gneisses to the destructive forces of the elements.

Structural Geology

Regional

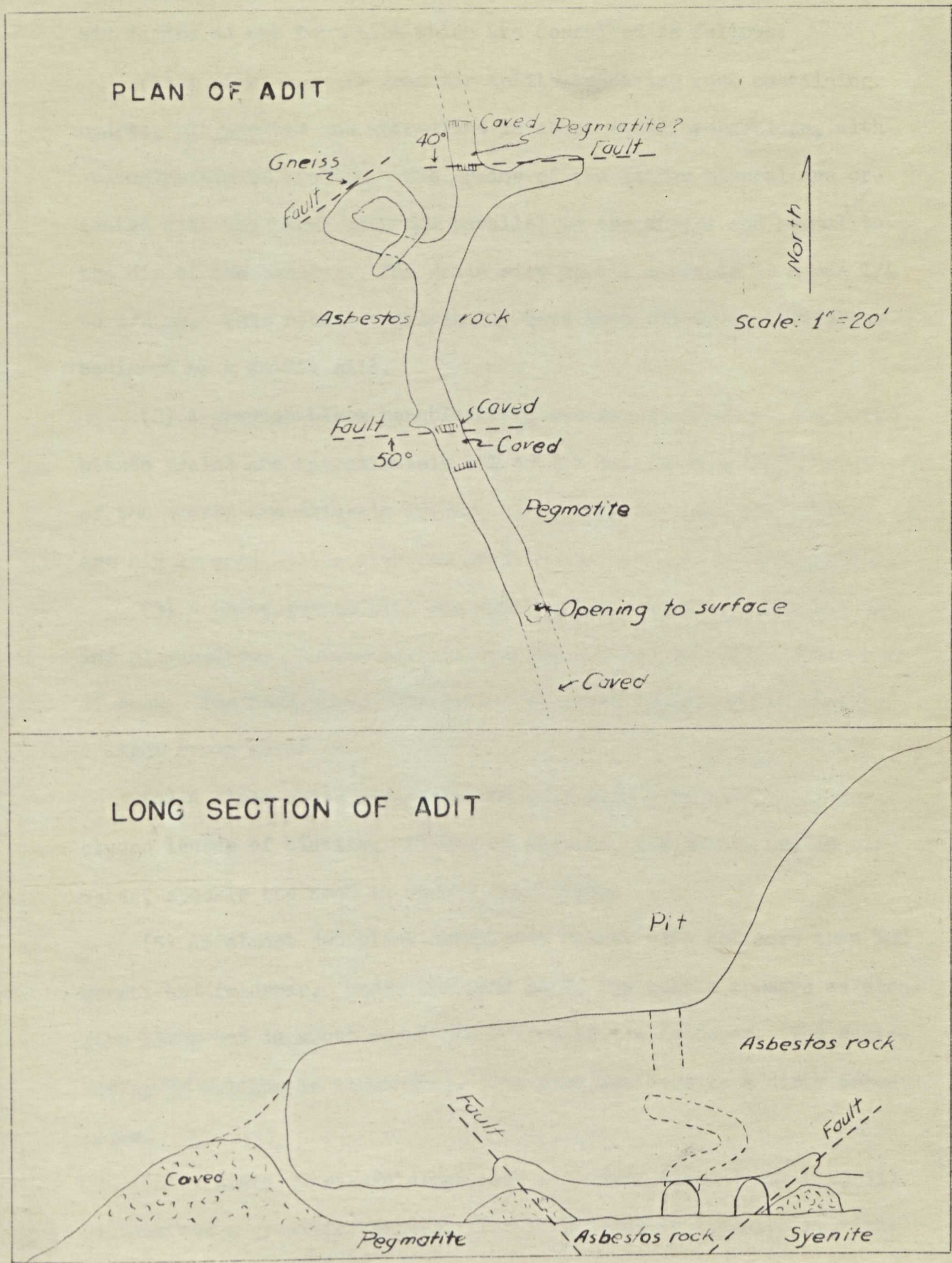
Faults of great vertical and horizontal magnitude, which have in many places forced Archean rocks into contact with those of Devenian or later time, are the main structural features noticed in the area. Many of the forces which produced some of these ruptures also caused the sediments to be highly folded and in places to be overturned. Axes of many of the larger of the anticlines have been eroded to such depth that the underlying Archean strata are exposed. The structure is further complicated by the presence of igneous rocks, which occur in the forms of laccolites, sills, dikes, and surface flows.

Local

The complexity of the local structures are beyond the scope of this paper, and the author has made no attempt to decipher them except in so far as they bear directly upon the occurance of the asbestos. The fibrous material occurs in a basic dike, but from the evidence at hand the igneous rock has been moved to its present position by two faults (Plate IV) which dip towards each other so that they would meet approximately 42 feet below the present floor of the pit. These faults both strike nearly east to west with the one on the north dipping 40° south and the other 50° north. The deposit is bounded on the west by a fault of undetermined dip and on the east by the schists and gneisses whose strike is N 40° W and whose dip is 77° NE. The general strike of the asbestos veins within the pit is due north and the dip is 79° west, whereas strikes of the country rock are N 10° E on the west side and N 27° E on the east side, with dips of 58° SW and 61° SW respectively. This indicates a fracture or fault through which mineralizing solutions could rise. The fibers within the veins are perpendicular to the enclosing walls, that is, nearly horizontal.

PETROLOGY

The Pony series of rocks in the vicinity of the asbestos deposit consist mainly of schists and gneisses. Because of the nature of these rocks it is impossible in the time available to determine whether they were originally sedimentary, as is probably the case with most of the material, or if they were igneous. The pit is bounded by



UNDERGROUND WORKINGS KARST ASBESTOS DEPOSITS

Modified from Eugene S. Perry, 1938

T.L.W., 1948

six facies of the formation which are described as follows:

(1) A pinkish-white granular aplite-appearing rock containing quartz, plagioclase and microcline in about equal proportions, with approximately 5% biotite. The grains of the latter mineral are oriented with the basal cleavage parallel to the strike and normal to the dip of the banding. The grain size of all minerals is about 1/4 to 1/2 mm. This rock may originally have been either an arenaceous sediment or a felsic sill.

(2) A grayish-black hornblende-quartz schist in which the hornblende grains are approximately 1/4 to 1/2 mm. in size while those of the quartz are slightly larger, being 1/2 to 1 mm. All grains are highly crystalline with the schistosity parallel to the banding.

(3) A white gneiss with the essential mineralogic component being plagioclase. Quartz and biotite are present in amounts less than 2% each. The rock tends to fracture at right angles and weather to a light brown color.

(4) A clear-white well-cemented quartzose band with small included lenses of biotite. Flakes of biotite, 1/8 to 1/4 mm. in diameter, speckle the rock in minute quantities.

(5) An almost jet black hornblende schist with not more than 10% quartz and feldspar. Under the hand lens, the quartz appears as elongate blebs and in about equal proportion to the feldspar. The schistosity is oblique to thebanding. The rock weathers to a dirty brown color.

(6) A white quartz-feldspar rock with very minor (less than 1%) biotite and a granitic texture. The rock tends to fracture at right angles and to weather to a rather fresh brown color.

An unmetamorphosed syenite dike lies 40 feet northwest of the pit (Plate V). This intrusive does not appear to be related to the occurance of the asbestos.

Pyroxenite is the name which has been given to the rock which contains the asbestos within the pit. In hand speciman it appears to consist almost entirely of green to brown enstatite. Some hydrothermally leached specimens of this rock have been altered almost entirely to kaolin, chlorite and limonite, the last proving the presence of iron bearing minerals. Along what appears to be two obscured fault planes, the pyroxenite has been altered to chlorite-rich schists with some sericite and biotite. Each of these occurances is 2 feet wide with individual grains oriented parallel to apparent slickensides.

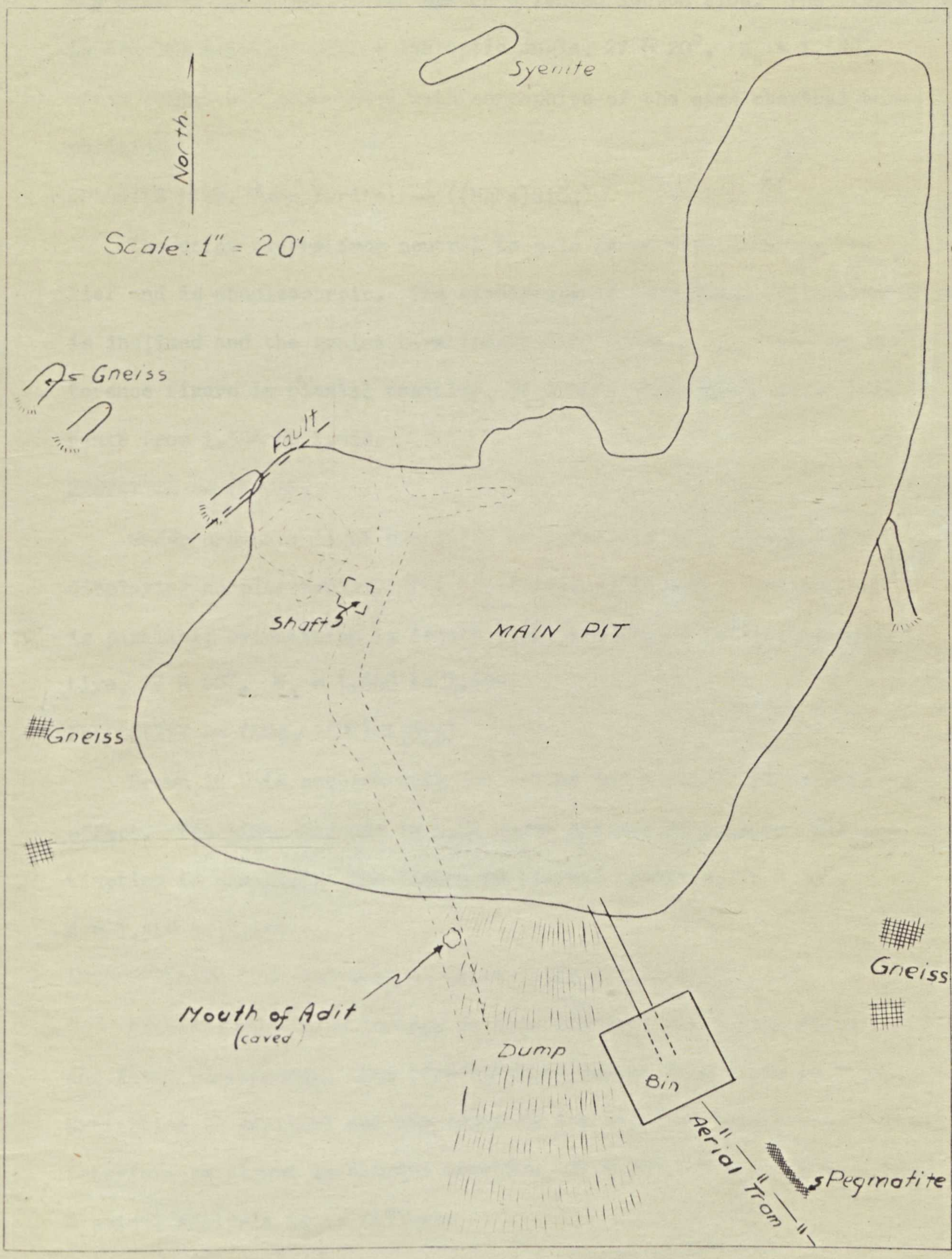
The asbestos in hand speciman appears to be a long fiber amphibole asbestos called anthophyllite (Plate VII, A, B, C). It ranges within the pit from a brownish-gray, hard, dense, "bone" variety to a high grade, pure white, easily fibered substance. There are often small inclusions of chlorite within this high grade material.

MINERALOGY

The pyroxenite host rock was studied under the petrographic microscope to determine the relationship of the vein asbestos to the gangue. Most of the minerals were first identified by use of small grains and later reidentified in thin sections made from the same samples from which the grains were taken. The descriptions of the minerals are as follows:

ANTIGORITE (var. Bastite) — ($H_4Mg_3Si_2O_9$)

The color of this mineral is pale green with low relief and is nonpleochroic. Under crossed nichols the birefringence is 0.009 and



SURFACE WORKINGS KARST ASBESTOS DEPOSITS

Modified from Eugene S. Perry, 1938 T.L.W., 1948 the mineral has parallel extinction oriented length slow. The figure is biaxial negative with a low optic angle, $2V \cong 20^{\circ}$. $N_a = 1.588$. Often intimately associated with serpophite of the same chemical composition.

CHLORITE (var. Prochlorite) -- ($(MgFe)SiO_3$)

The color ranges from neutral to pale green with moderate relief and is nonpleochroic. The birefringence is 0.004. Extinction is inclined and the grains have length slow orientation. The interference figure is biaxial positive, $2V \cong 40^{\circ}$. Indices of refraction range from 1.588 to 1.612.

ENSTATITE -- ($MgSiO_3$)

Under ordinary light enstatite is colorless with a high relief, displaying no pleochroism. The birefringence is 0.009; extinction is parallel; orientation is length slow; the figure is biaxial positive, $2V \cong 60^{\circ}$. $N_a = 1.640$ to 1.659.

PHLOGOPITE -- ($KMg_3Al(OH)Si_4O_{10}$)

Brown in thin section with low relief and a slight pleochroic effect. The birefringence is 0.04 under crossed nichols and the extinction is parallel. The figure is biaxial positive, $2V \cong 80^{\circ}$. $N = 1.549$ to 1.558

ANTHOPHYLLITE (var Gedrite) -- ($H_2Ca_2(MgFe)_3Al_4Si_6O_{24}$)

Anthophyllite is colorless in thin section, has a high relief and faint pleochroism. The birefringence ranges from 0.014 to 0.025. Extinction is parallel and the crystals are oriented length slow. The interference figure is biaxial negative, $2V \cong 80^{\circ}$. $N = 1.608$ to 1.627. Chemical analysis is as follows:

SiO_2	— 56.06%
FeO	— 9.80
Al_2O_3	— 5.84
CaO	— 1.22
MgO	— 26.02
Ign. loss	— 1.98

TOURMALINE (var. Schorlite) — $(NaFe_3B_3Al_3(OH)_4(Al_3Si_6O_{27}))$

Schorlite is colorless with high relief and marked pleochroism. Under crossed nichols the birefringence ranges from 0.022 to 0.036; the extinction is parallel; the orientation is length fast; and the figure is uniaxial negative. $N_e = 1.659$.

MAGNETITE — $(Fe^{II}Fe_2^{III}O_4)$

This mineral is opaque with a blue-black color and is strongly magnetic. It is found as angular inclusions in the pyroxenite, very seldom in the asbestos.

MINERALIZATION

Ore Zone

The asbestos occurs in a pyroxenite dike which is discordent with the surrounding schists and gneisses. The pyroxenite country rock consists mainly of enstatite with associated phlogopite and schorlite (tourmaline). From a distance, the outcrop of this material has a greenish-black appearance, but on closer observation it can be seen that actually the rock is made up of bands (Plate VI), apparently along fracture planes. Individually these bands are made up of 4 to 8 inches of a greenish-brown enstatite which has a vitreous luster and appears to be slightly fibrous, separated by nearly 2 feet of dull black high-iron enstatite. In general, these bands strike N 10° E across the deposit and dip 58° SW in the central portion, but elsewhere strike N 27° E, with a dip of 61° SW. The planes separating the pyroxenite

A.-- Main pit looking north. White bands are asbestos veins cutting pyroxenite country rock.

B.-- Middle pit, one-quarter mile southwest of main pit, looking northwest. White band crossing center of photograph from left to right is asbestos vein.

C.-- West pit, 100 yards southwest of middle pit, looking north. White band in center of picture is asbestos vein showing cross-fiber structure.

PHOTOGRAPHS OF PITS IN ASBESTOS-BEARING ROCK of one attitude from that of another are occupied by veins of clearly defined asbestos. These veins range from 2 inches to 2 1/2 feet in width, and they show no gradation from the fibrous material into the solid country rock.

The zone is intimately associated on the north and south sides with pegmatites. So far as is known, this is not true for the western pits.

Origin

The origin of the asbestos must be considered from two angles: first, the origin of the mineral and, secondly, the formation of the fibrous nature of the material.

It has been postulated that anthophyllite is formed from enstatite purely by paramorphism, that is, merely a physical change, not a chemical transformation. This would necessarily have to be accomplished under conditions of great temperature and pressure since the break-down temperature of enstatite under laboratory conditions is 1557°C. However, this hypothesis is contradicted by Alfred Harker* who states, ".... thus taking the simple magnesian metasilicates, we find for enstatite the specific gravity 3.175 and for anthophyllite 2.857, from which it is evident that the formation of the amphibole rather than the pyroxene in crystalline schists cannot be attributed to mere hydrostatic pressure." He also proves that dynamic metamorphism of enstatite will tend to produce talc instead of serpentine which, as will be shown later, is an intermediate alteration product of enstatite into anthophyllite. Furthermore, it has been shown that, as in the case of the Georgia deposits, regional metamorphism, which

*Harker, Alfred, <u>Metamorphism,</u> Methuen and Co., Ltd., London, 1939, p. 151.

PLATE VII

A.-- Hand specimens of asbestos. Upper two "bone" variety; bottom two "high-grade." Lower left specimen shows curved fibers due to differential pressure on walls.

B.-- Speciman showing relationship of cross-fiber vein to wall rock. Approximately one-half natural size.

C.-- "High-grade" easily fibered asbestos. Approximately one-half natural size.

D.-- Photomicrograph showing antigorite (dark area) altering to anthophyllite. Section made at asbestos-pyroxenite contact. Crossed nichols. X27.

E.-- Same field as photomicrograph "D" with plain nichols. X27.

PLATE VII

A.

B.

C.

D.

E.

PHOTOGRAPHS OF ASBESTOS

has implications of both dynamic and hydrostatic pressures, produces lenses of mass- or bundle-fiber whereas the Karst deposits consist wholly of cross-fiber veins (Plate VII, B).

Anthophyllite but rarely occurs in the cross-fiber form, therefore a different explanation for its occurance must be sought. Many hypotheses have been formulated for the formation of cross-fibers in veins, but in late years the idea of lateral secretion from the walls to a fracture or fault has taken hold, the growing veins actually applying such stress to the walls that they are pushed apart.

Since pyroxenes are most stable under static conditions of high temperatures and anthophyllite stable under conditions of differential pressure and somewhat lower temperatures, the transition must have taken place at depth in a fault zone (shown by the differences in attitudes of the host rock) aided by the prompting of an aqueous-siliceous fluid which found the fault planes accessable escapeways from an underlying magma. The solutions altered the host rock and formed the asbestos, partly from the constituents of the rock, the individual crystals pushing the walls apart as they grew. Rarely, the fibers in the Karst veins are curved (Plate VII, A). This has been attributed to a gradual differential displacement of the walls. As enstatite alters to serpentine there is an increase in volume, but this is not likely to have caused much exertion of pressure because some of the products of alteration are removed by the circulating solutions.

The formation of fibers within the amphibole minerals is due to physical conditions which have limited crystal growth to one direction, accentuated by normal prismatic habit and cleavage. It is thought that this is attributable primarily to the fact that the material from which the growing crystals were built was accessible only in one direction. Recent weathering has caused the fibers in shallow portions of veins to become softer and less brittle, producing "high-grade" fibers (Plate VII, C).

Paragenesis

It has already been inferred that enstatite was the mineral from which the anthophyllite was formed and that the elemental constituents of the latter were derived not only from the rock, but from the solutions of alteration as well. The transition took place in two steps: first, enstatite to antigorite (bastite) and, secondly, antigorite to anthophyllite (gedrite). The alteration of enstatite to the serpentine can be accomplished merely by the addition of super-heated water. This is shown in the following chemical equation in which the excess silica is removed by solution:

$$3MgSiO_3 + 2H_2O \longrightarrow H_4Mg_3Si_2O_9 + SiO_2.$$

The antigorite was further acted upon by liquors which contained the constituents of kyanite and wollastonite, both common pegmatitic minerals, to produce the variety of anthophyllite present in the deposit (Plate VII, D, E). This chemical reaction can be shown as follows:

$$2H_4Mg_3Si_2O_9 + 2Fe_3O_4 + 4Al_2SiO_5 + 4\ CaSiO_3 \longrightarrow 2H_2Ca_2(MgFe)_3Al_4Si_6O_{24} + 2H_2O + 2O_2.$$

The magnetite shown in the above equation was probably an original constituent of the altered rock.

Prochlorite was produced by the alteration of the excess iron-rich enstatite in a manner shown below:

$$5(MgFe)SiO_3 + Al_2O_3 + 4H_2O \longrightarrow H_8(MgFe)_5Al_2Si_3O_{18} + 2SiO_2.$$

These several equations have been independently formulated by the writer, however, the first and last are also given by Hopkins*.

*Hopkins, Oliver B., A Report on the Asbestos, Talc and Soapstone Deposits of Georgia, Georgia Geological Survey Bull. 29, pp. 65 and 69.

ECONOMIC CONSIDERATIONS

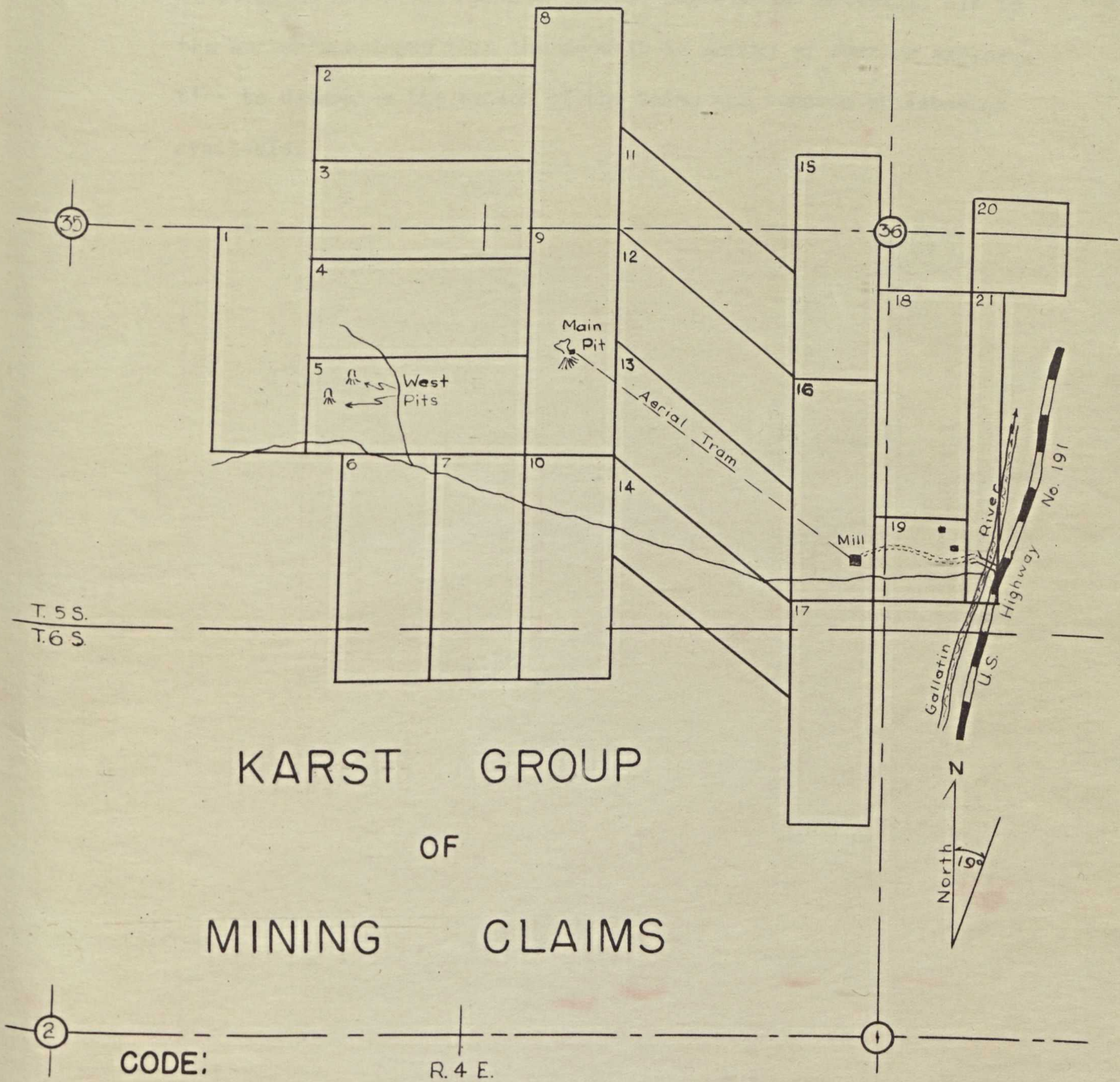
The U.S. Bureau of Mines reported in 1934 that some samples sent to them from the Karst deposits proved to be of exceptional quality. They stated that the fibers averaged one-half inch in length and is the only known anthophyllite (amphibole asbestos) in the United States of spinning quality. Ordinarily, the serpentine asbestos is considered the spinning variety. In the past, asbestos from the Karst deposit has sold for $40 per ton at the mine. The deposit consists of approximately 35% fiber.

It is very difficult to estimate the quantity of asbestos present because of the complex nature of the entire region, therefore it would be highly unwise to make great expenditures for physical plants and surface equipment until a detailed exploratory and development program had taken place. However, since all the minerals present are of the high temperature variety, it would be quite right to assume that the veins continue to depth provided they are not displaced by faults. The fibers would become harsher and of inferior quality with increasing depth, however, because it is unlikely weathering would reach beyond a hundred feet in this region.

CONCLUSIONS

The Karst Kamp asbestos deposits consist of a variety of anthophyllite called "gedrite", and was formed in pre-Cambrian time by the action of silicic fluids upon a pyroxenite host rock, causing the essential constituent, enstatite, to hydrothermally alter under conditions of great pressure and temperature to asbestos. This material is commonly called amphibole asbestos. Later elevation of the deposit and subsequent erosion of the overlying rock enabled weathering

PLATE VIII



CODE:

1. Utah	8. Blue Jay	15. Pine
2. Texas	9. Karst	16. Six Bit
3. Last Chance	10. Creek	17. Idaho
4. Discovery	11. Ash	18. River Side
5. Montana	12. Elk	19. Mill Site
6. Gallatin	13. Buck	20. " "
7. Mountain Top	14. Spruce	21. " "

By W. B. Vestle

Scale: 1 in. = 1000 ft.

T.L.W., 1948

to separate the fibers into a fluffy "high-grade" material. It is the author's opinion that the deposit is worthy of further exploration to determine the extent of the veins and tonnage of asbestos available.

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